the architecture of sustainable design

Materials and Resources

Spirit and SDD training course

Green vs. Sustainable

- Green Performance
  - the environmental building performance of a building relative to typical practices for that building type and region.

- Environmental Sustainability
  - the absolute performance in a selected set of performance criteria in contrast with other buildings in different regions
    - broader and more global concept that incorporates planning, ecological, and landscape related ideas (and ideals)

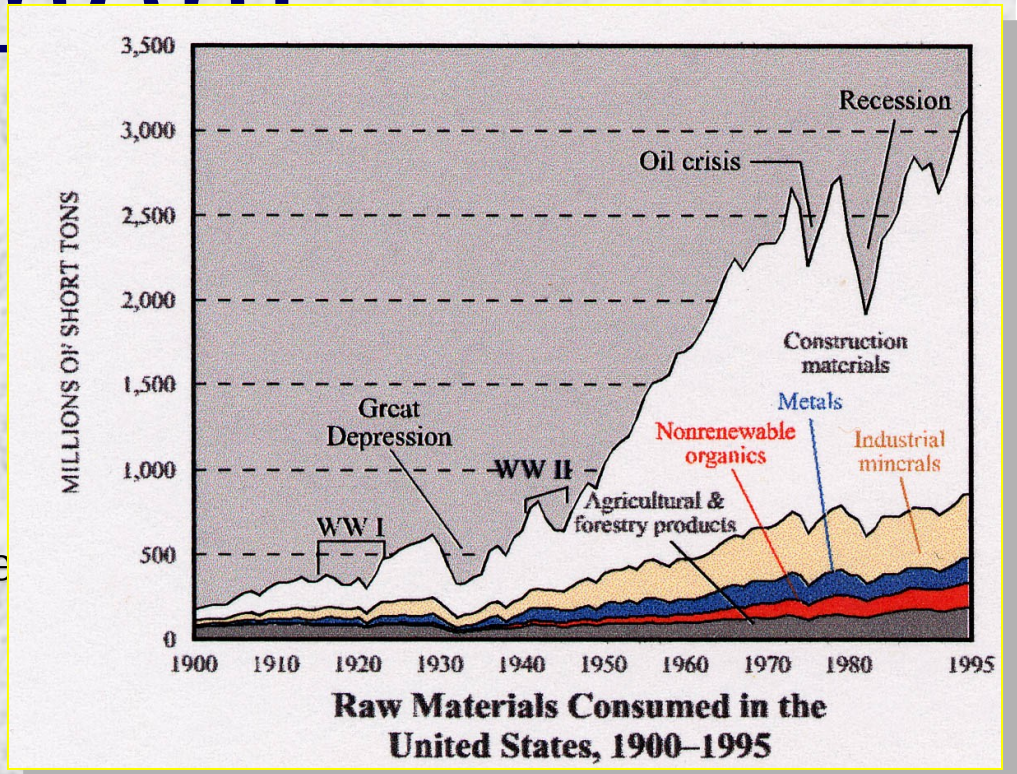
- a green material is more environmentally friendly than materials typically used
- a sustainable materials' performance is related to global scales and impacts

Materials Resources

- The industrialized world comprises only 20 percent of the world's population, yet consumes 86 percent of the world's aluminum, 81 percent of its paper, 80 percent of its iron and steel, and 76 percent of its timber (Worldwatch Institute, 1994)
- The average materials use by an American—including all industrial raw materials, fertilizers for food, etc. - is 223 pounds (101 kg) per day.
- There was a 2.4-fold increase in world materials production between the early 1960s and 1995.
- Even though materials intensity - material use per dollar of output - dropped 18% worldwide between 1970 and 1995, total consumption of materials jumped 67%.

The Built Environment

- Each year the construction, renovation and operation of buildings consume:
  - 40% of the raw materials
  - 32% of the total energy produced
  - 17% of all fresh water use
  - 25% of the global wood harvest.
- This results in tens of millions of tons of greenhouse gases, air water pollution, and wastes.



Raw Materials Consumed in the United States, 1900–1995

The construction industry consumes 60% of all non-food and non-fuel raw materials in the U.S.

Buildings and Materials

From 1970 to the present, the U.S. has been consuming about 1/3 of the world's total materials production

- There are more than 76 million residential buildings and nearly 5 million commercial buildings in the U.S. today
- Another 38 million buildings are expected to be constructed by 2010 (doe)
  - The challenge will be to build them intelligently, so that they use a minimum of nonrenewable energy, produce a minimum of pollution and wastes, and cost a minimum of energy dollars, while increasing the comfort, health, and safety of the people who live and work in them.

Sustainable Materials attributes

- reduce pollution and waste in the manufacturing process
- have a high recycled content
- are recyclable
- have low lifecycle impacts
- have low embodied energy
- are non-toxic or less toxic
- require little maintenance
- are durable
- use renewable resources
- use local resources
- is a reusable resource
- uses sustainable manufacturing /harvesting practices

Recyclable Materials

- Recycling a ton of steel will prevent
  - 25 tons of water use, nearly three tons of mining waste, 200 pounds of air pollutants and 100 pounds of water pollutants (ILSR)
- A ton of resmelted aluminum
  - forgoes the need for four tons of bauxite and nearly a ton of petroleum coke
- Burning a ton of paper
  - releases 1,500 pounds of the greenhouse gas, carbon dioxide (CO_2)
- Recycling a ton of paper saves 17 trees and absorbs 250 pounds of CO_2 annually

SPiRiT Materials and Resources

- SPiRiT has one prerequisite and 7 credits associated with materials and resources for a total of 13 points.
- They focus mainly on:
  - Waste issues
  - Recycled and reuse content
  - Renewable
  - Local sources

Storage and Collection of Recyclables

prerequisite

- Intent:
  - Facilitate the reduction of waste generated by building occupants that is hauled to and disposed of in landfills.
- Requirement:
  - Provide an easily accessible area that serves the entire building that is dedicated to the separation, collection and storage of materials for recycling including (at a minimum) paper, glass, plastics, and metals .

Storage and Collection of Recyclables

- Technologies/strategies:
  Establish a waste management plan. Reserve space for recycling functions early in the building occupancy programming process and show areas dedicated to collection of recycled materials on space utilization plans. Broader recycling support space considerations should allow for collection and storage of the required elements and newspaper, organic waste (food and soiled paper), and dry waste. When collection bins are used, bin(s) should be able to accommodate a 75% diversion rate and be easily accessible to custodial staff and recycling collection workers. Consider bin designs that allow for easy cleaning to avoid health issues.

Recycled Materials

- Energy
  - 90% less energy is needed for re-manufacturing aluminum or plastics, 50 % for steel or paper and of 30% for glass
  - Each year, steel recycling saves the energy equivalent to electrically power about one-fifth of the households in the United States (or about 18 million homes) for one year
- Water
  - Far less air and water pollution is generated in re-manufacturing: reductions of 95% for aluminum, 85 and 76 percent for steel, 74 and 35 percent for paper

Cumulative energy savings would amount to seven quads and $30 billion, if recycling rates increase 10 percent above the projected level for 1992 and 30 percent above the projected level for 2008 (Seldman and Geller)

Recycled Content

materials credit

intent

- Increase demand for building products that have incorporated recycled content material, reducing the impacts resulting from extraction of new material.

requirement:

- Specify a minimum of 25% of building materials that contain in aggregate a minimum weighted average of 20% post-consumer recycled content material, OR, a minimum weighted average of 40% post-industrial recycled content material. (1 point)
- Specify an additional 25% (50% total) of building materials that contain in aggregate, a minimum weighted average of 20% post consumer recycled content material, OR, a minimum weighted average of 40% post-industrial recycled content material. (1 point)

Recycled Content

technologies/strategies:

- Specify building materials containing recycled content for a fraction of total building materials. Select products and materials with supporting information from the AIA Resource Guide or the EPA Environmentally Preferable Purchasing (EPP) Program. Common building materials and products with recycled content include; wall, partition, and ceiling materials and systems; insulation; tiles and carpets; cement, concrete, and reinforcing metals; structural and framing steel.

* Exclusions: Labor costs; all mechanical and electrical material and labor costs; project overhead and fees

Recycled Content

- See the LEED Reference Guide for a summary of the EPA guidelines and calculation methodology guidelines. Determine percentages in terms of dollar value using the following steps:
  - 1. Calculate total dollars (see exclusions) of the material that contain recycled content.
  - 2. Calculate total dollars (see exclusions) of all building materials.
  - 3. Divide Step 1 by Step 2 to determine the percentage.
  - Exclusions: Labor costs; all mechanical and electrical material and labor costs; project overhead and fees)

EPA's Comprehensive Procurement Guidelines (CPG).

Environmental Protection Agency
40 CFR Part 247

Comprehensive Guideline for Procurement of Products Containing Recovered Materials; Recovered Materials

Advisory Notice III; Final Rule

- www.epa.gov/epaoswer/non-

the EPA selection criteria of items for designation:

- use of materials found in solid waste
- economic and technological feasibility and performance
- impact of government procurement
- availability and competition
- other uses for recovered materials

Construction Waste

- 2 to 7 tons of waste (4 lbs/sf) are generated constructing a single-family detached house
- 15 to 70 pounds of hazardous waste are generated constructing a single-family detached house
  - hazardous wastes include paint, caulk, roofing cement, aerosols, solvents, adhesives, oils, and greases.
- U.S. builders produce 30 -35m tons of C&D waste each year
  - 24% of the municipal solid waste stream
- 95% of construction waste is recyclable

Mix them and you get garbage, separate them and you get resources.

Construction Waste Management

- landfill taxes in Denmark have boosted construction debris recycling from 12% to 82% in just eight years
- close the “subsidy spigot” for extractive activities
  - the 1872 Mining Law in the U.S. gives mining companies access to public land for just $5/acre ($12/ha) without paying royalties or even clean-up
- tax pollution and waste
- encouraging the shift to a service economy in which companies maintain responsibility for products and materials throughout their life cycles

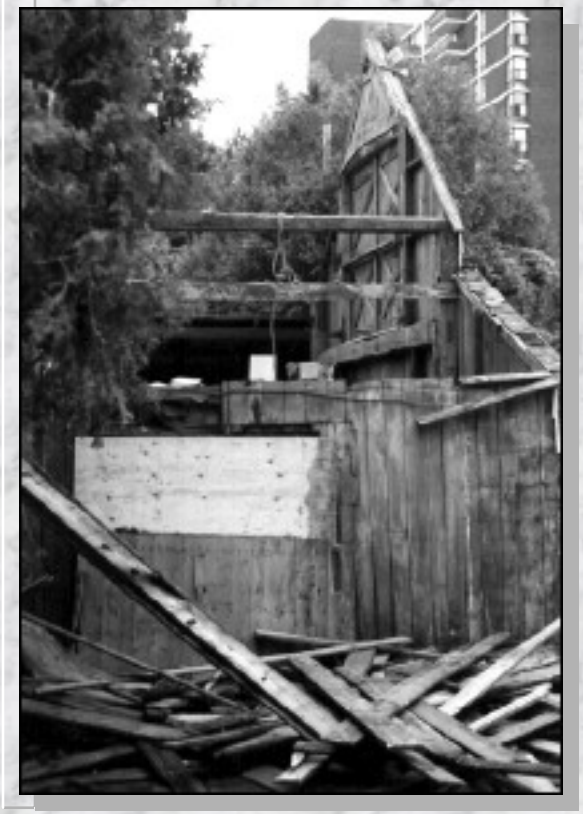
Construction Waste Management materials credit

- Intent:
  - Divert construction, demolition, and land clearing debris from landfill disposal.
  - Redirect recyclable material back to the manufacturing process.
- Requirement:
  - Develop and implement a waste management plan, quantifying material diversion by weight.
    - Recycle and/or salvage at least 50% (by weight) of construction, demolition,and land clearing waste. (1 point)
    - Recycle and/or salvage an additional 25% (75% total by weight) of the construction, demolition, and land clearing debris. (1 point)

Construction Waste Management

- Technologies/strategies:
  - Develop and specify a waste management plan that identifies licensed haulers and processors of recyclables; identifies markets for salvaged materials; employs deconstruction, salvage, and recycling strategies and processes, includes waste auditing; and documents the cost for recycling, salvaging, and reusing materials.
  - Source reduction on the job site should be an integral part of the plan
    - The plan should address recycling of corrugated cardboard, metals, concrete brick, asphalt, land clearing debris (if applicable), beverage containers, clean dimensional wood, plastic, glass, gypsum board, and carpet, and evaluates the cost-effectiveness of recycling rigid insulation, engineered wood products and other materials. Refer to the LEED Reference Guide for guidelines and references that provide waste management plan development and implementation support including model bid specifications.

Construction Waste Management



- deconstruction

The Building Life Cycle

appropriate sustainable strategies require actions to be taken at each stage of a building's life cycle

- 1. Planning
  - Project Initiation
  - Programming
  - Site Selection
- 2. Design
  - Schematic Design
  - Design Development
  - Const Documents / Specs
- 3. Construction
  - Bidding and Award
  - Construction
  - Commissioning
- 4. Occupancy
  - Start Up
  - O & M
  - Re-Commissioning
- 5. Next Use

conservation opportunities are typically analyzed solely on economics, human factors should also be considered.

Current End-Use Practice

Adaptive Reuse

Ft Riley Kansas

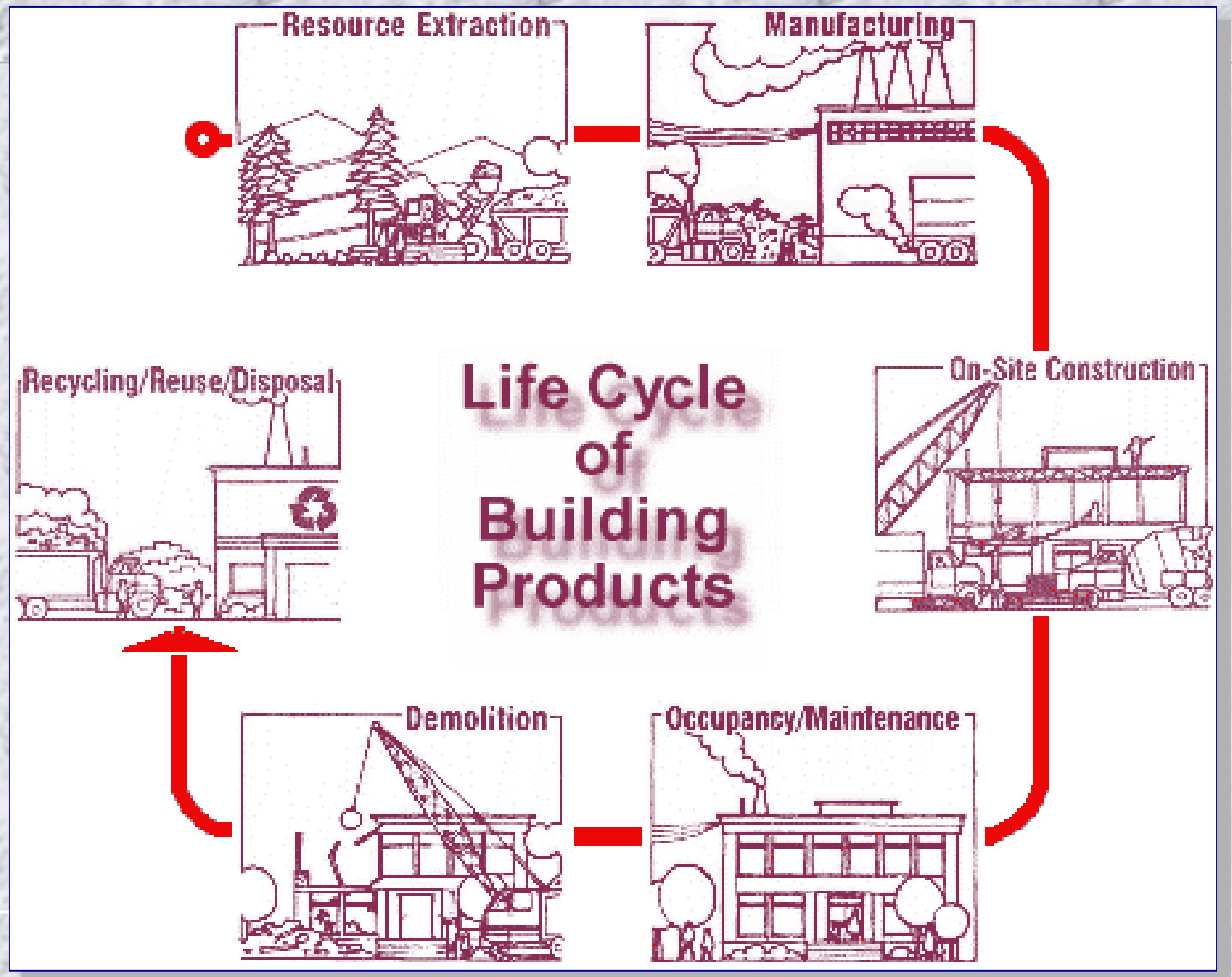
Building Reuse
materials credit

- Intent:
  - Extend the life cycle of existing building stock, conserve resources, retain cultural resources, reduce waste, and reduce environmental impacts of new buildings as they relate to materials manufacturing and transport.
- Requirement:
  - Reuse large portions of existing structures during renovation or redevelopment projects.
    - Maintain at least 75% of existing building structure and shell (exterior skin and framing excluding window assemblies). (1 point)
    - Maintain an additional 25% (100% total) of existing building structure and shell (exterior skin and framing excluding window assemblies). (1 point)
    - Maintain 100% of existing building structure and shell AND 50% non-shell (walls, floor coverings, and ceiling systems). (1 point)

Building Reuse

- Technologies/strategies:
  - Evaluate retention of existing structure. Consider facade preservation, particularly in urban areas. During programming and space planning, consider adjusting needs and occupant use patterns to fit within existing building structure and interior partition configurations. Identify and effectively address energy, structural, and indoor environmental (lead & asbestos) issues in building reuse planning and deconstruction documents. Percentage of reused non-shell building portions will be calculated as the total area (s.f.) of reused walls, floor covering, and ceiling systems, divided by the existing total area (s.f.) of walls, floor covering, and ceiling systems.

Resource Reuse



Life Cycle Analysis - LCA

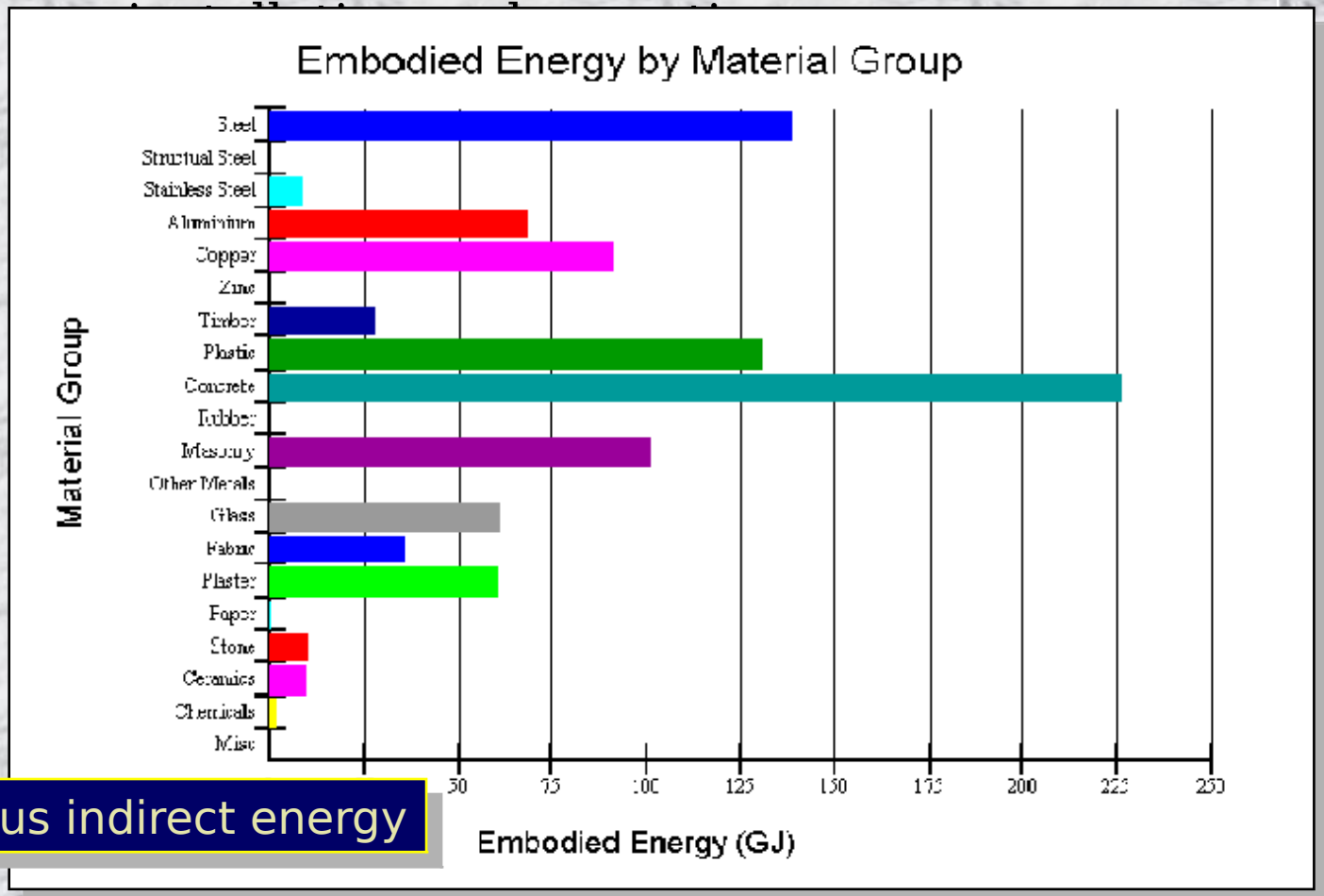
Life cycle impacts are measured by evaluating the environmental impacts of materials through its entire "life cycle" from initial production through eventual reuse, recycling or disposal.

- Life cycle costs calculation
  - First costs
    - capital investment
    - purchase costs
    - installation
  - Future costs
    - energy
    - operation
    - maintenance
    - capital replacement
  - Disposal
    - salvage value
- Externalities
  - environmental degradati
    - pollution
    - health risks
  - carbon cycle impacts
  - global warming
- Time Component
  - Present Worth
  - Discount rates
    - personal discounting
    - community discountin

$$LCI = \frac{((F_c + F_u - D_i) + E_x)}{time}$$

Embodied Energy

- The energy required by all of the activities associated with a product, including



Direct energy plus indirect energy

Embodied Energy

- Where/how does the material originate?
- How is the material processed?
  - some processes use coal, others use gas, and some use a mixture of fuels including waste tires
    - so production greenhouse gas emissions /other environmental impacts vary!
      - energy-efficient cement manufacturing plants consume less than 3.5 GJ of direct end-use energy per ton of cement
      - least efficient plants require up to 8 GJ per ton
- How is the material transported
  - from where?
- How is the

	Heating Energy MMBtu/year (Gj/year)	Embodied Energy MMBtu (Gj)	Embodied Energy Expressed as years of heating energy
Conventional house, Vancouver	101 (107)	948 (1,000)	9.4
Conventional house, Toronto	136 (143)	948 (1,000)	7.0
Energy-efficient version, Vancouver	57 (60)	1,019 (1,075)	17.9
Energy-efficient version, Toronto	78 (82)	1,019 (1,075)	13.1

Resource Reuse

materials credit

intent:

- Extend the life cycle of targeted building materials, reducing environmental impacts related to materials manufacturing and transport.

requirement:

- Specify salvaged or refurbished materials for 5% of building materials. (1 point)
- Specify salvaged or refurbished materials for 10% of building materials. (1 point)

Resource Reuse

technologies/strategies:

- Commonly salvaged building materials include wood flooring/ paneling/cabinets, doors and frames, mantels, iron work and decorative lighting fixtures, brick, masonry and heavy timbers. See the LEED Reference Guide for calculation tools and guidelines. Determine percentages in terms of dollar value using the following steps:
  - 1. Calculate total dollars* of the salvaged or refurbished material.
  - 2. Calculate total dollars* of all building materials.
  - 3. Divide Step 1 by Step 2 to determine the percentage.
    - Exclusions: In total dollar calculations, exclude; labor costs; all mechanical and electrical material and labor costs; and project overhead and fees.

*If the cost of the salvaged or refurbished material is below market value, use replacement cost to estimate the material value, otherwise use actual cost to the project.

Use Local Resources

- Increases local economic impacts of project
- Reduces total embodied energy
  - reduces travel costs/impacts
- Reduces total LCI
  - keeps externality related impacts local
    - more likely to reduce environmental impacts
- Historically proven techniques
  - will reduce operational and environmental impacts

Local/Regional Materials

materials credit

intent:

- Increase demand for building products that are manufactured locally, reducing the environmental impacts resulting from transportation, and supporting the local economy.

requirement:

- Specify a minimum of 20% of building materials that are manufactured regionally within a radius of 500 miles. (1 point)
- Of these regionally manufactured materials, specify a minimum of 50% that are extracted, harvested, or recovered within 500 miles. (1 point)

Local/Regional Materials

technologies/strategies:

- Specify and install regionally extracted, harvested, and manufactured building materials. Contact the state and local waste management boards for information about regional building materials. Determine percentages in terms of dollar value using the following steps:
  - 1.Calculate total dollars* of material that is locally or regionally manufactured.
  - 2.Calculate total dollars* of all building materials.
  - 3.Divide Step 1 by Step 2 to determine the percentage.

* Exclusions: Labor costs; all mechanical and electrical material and labor costs; project overhead and fees

Rapidly Renewable Materials

intent:

materials credit

- Reduce the use and depletion of finite raw and long cycle renewable materials by replacing them with rapidly renewable materials.

requirement:

- Specify rapidly renewable building materials for 5% of total building materials.

Rapidly Renewable Materials

technologies/strategies:

- Rapidly renewable resources are those materials that substantially replenish themselves faster than traditional extraction demand (e.g. planted and harvested in less than a 10 year cycle) and do not result in significant biodiversity loss, increase erosion, air quality impacts, and that are sustainable managed.
- Determine percentages in terms of dollar value.

Certified Wood
materials credit

intent:

- Encourage environmentally responsible forest management.

requirement:

- Use a minimum of 50% of wood-based materials certified in accordance with the Forest Stewardship Council guidelines for wood building components including but not limited to framing, flooring, finishes, furnishings, and non-rented temporary construction applications such as bracing, concrete form work and pedestrian barriers.

Certified Wood

technologies/strategies:

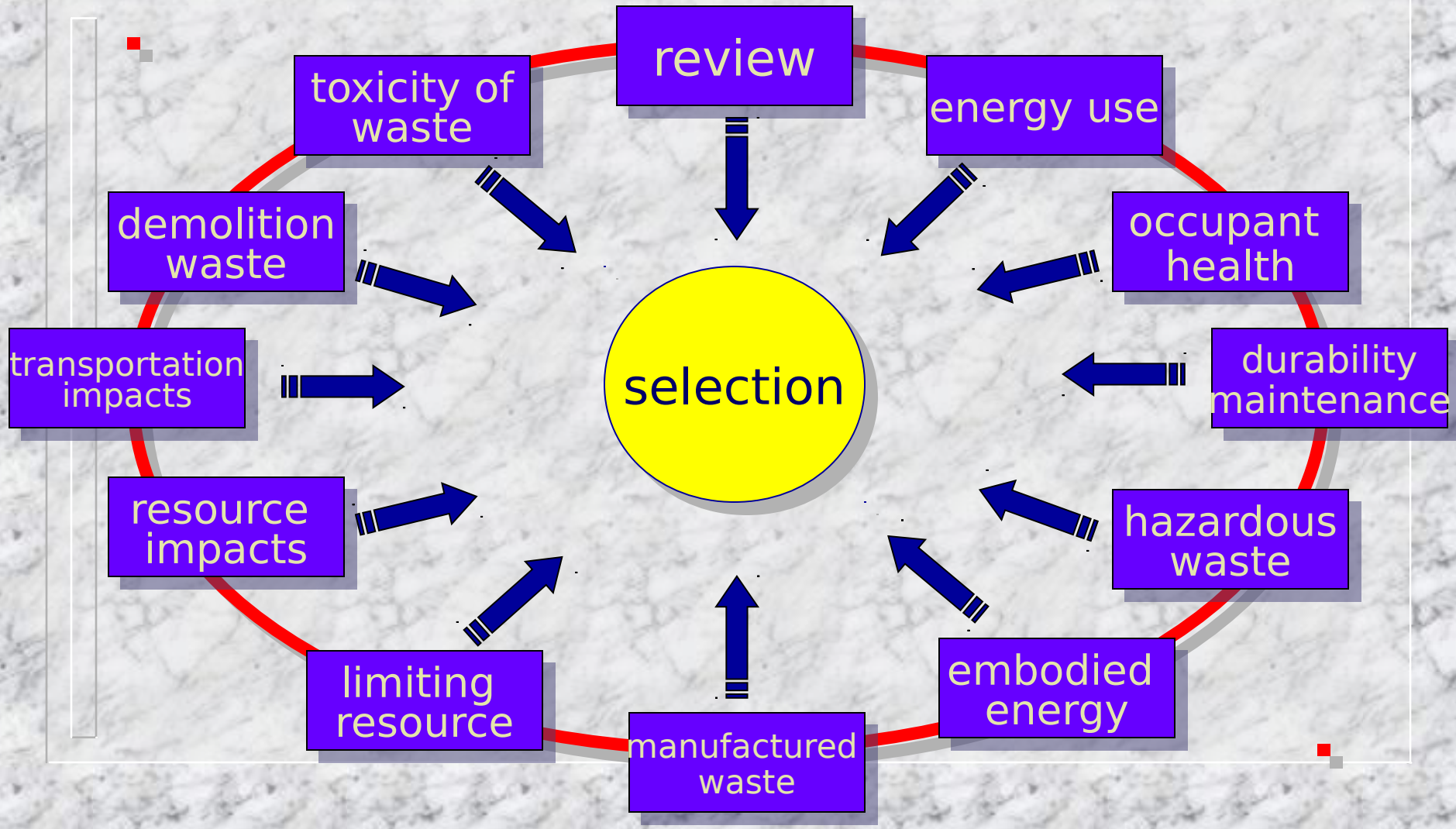
- Refer to the Forest Stewardship Council guidelines for wood building components that qualify for compliance to the requirements and incorporate into material selection for the project.

Materials Selection

environmentally preferable materials - EPM

- Most available EPM's have specific environmental attributes that separate them from competing products - they are good 'green performers'. These attributes may only apply to one of the products life cycle stages, but not to the entire life of the product. Some products that possess green attributes in one stage may have negative environmental attributes in another.
  - high embodied energy but low operational energy consumption
  - photovoltaic solar collectors may have extremely highly toxic manufacturing and disposal impacts
  - some products that include recycled material cannot be recycled themselves

Materials Selection



Selecting Appropriate Materials

phase 1 - use

step 1 – energy use:

- Will the material in question (in the relevant application) have a measurable impact on building energy use? If not, proceed to step 2.
  - If yes (as for materials such as glazing,insulation, mechanical systems), avoid options that do not minimize energy use. Also take care to design the application to minimize energy use. For materials that can be used in an energy-efficient manner only with the addition of other components, the impact of including those additional components must be factored in. Examples include glazing systems that require exterior shading systems for efficiency, and light-gauge steel framing that requires foam sheathing to prevent thermal bridging.

Selecting Appropriate Materials

phase 1 – use

step 2 – occupant health:

- Might products in this application affect the health of building occupants? If not, proceed to step 3.
  - If yes (interior furnishings, interior finishes, mechanical systems), avoid materials that are likely to adversely affect occupant health, and design systems to minimize any possible adverse effects when sources of in-door pollution cannot be avoided.

Selecting Appropriate Materials

phase 1 - use

step 3 – durability and maintenance:

- Are products in this application likely to need replacement, special treatment, or repair multiple times during the life of the structure? If not,proceed to step 4.
  - If yes (roofing, coatings, sealants), avoid products with short expected life spans (unless they are made from low-impact, renewable materials and are easily recycled), or products that require frequent, high impact maintenance procedures. Also, design the structure for flexibility so that materials that might become obsolete before they wear out (such as wiring) can be replaced with mini-mal disruption and cost.

Selecting Appropriate Materials

phase 2 – process

step 4 – hazardous by-products:

- Are significant toxic or hazardous intermediaries or by-products created during manufacture, and if so, how significant is the risk of their release to the environment or risk of hazard to worker health? If these are not significant, proceed to step 5.
  - Where toxic by-products are either generated in large quantities or in small but uncontrolled quantities (smelting of zinc, production of petrochemicals), the building material in question should be avoided if possible, or sourced from a company with strong environmental standards.

Selecting Appropriate Materials

phase 2 – process

step 5 – manufacturing energy:

- How energy-intensive is the manufacturing process? If not very intensive, proceed to step 6.
  - If the manufacture of a building material is very energy-intensive compared to the alternatives (aluminum, plastics), its use should be minimized. It is not the energy use itself that is of concern, however, but the pollution from its generation and use; industries using clean-burning or renewable energy sources have lower burdens than those relying on coal or petroleum.

Selecting Appropriate Materials

phase 2 – process

step 6 – waste from manufacturing:

- How much solid waste is generated in the manufacturing process? If not much relative to the quantity of product manufactured, proceed to step 7.
  - If significant amounts of solid waste are generated that are not readily usable for other purposes (tailings from mining of copper and other metals), seek alternative materials, or materials from companies with progressive recycling programs.

Selecting Appropriate Materials

phase 3 – raw materials

step 7 – resource limitations:

- Are any of the component materials from rare or endangered resources? If not, proceed to step 8.
  - If yes (endangered or threatened tree species), avoid these products, unless they can be sourced from recycled material.

Selecting Appropriate Materials

phase 3 -raw materials

step 8 – impacts of resource extraction:

- Are there significant ecological impacts from the process of mining or harvesting the raw materials? If not, proceed to step 9.
  - If yes (damage to rainforests from bauxite mining for aluminum, or from certain timber harvesting practices), seek suppliers of material from recycled stock, or those with credible third-party verification of environ-mentally sound harvesting methods.

Selecting Appropriate Materials

phase 4 – raw materials

step 9 – transportation:

- Are the primary raw materials located a great distance from your site? If not, proceed to step 10.
  - If yes (Italian marble, tropical timber, New Zealand wool), seek appropriate alternative materials from more local sources.

Selecting Appropriate Materials

phase 5 - next use

step 10 – demolition waste:

- Can the material be easily separated out for reuse or recycling after its useful life in the structure is over? If so, proceed to step 11.
  - While most materials that are used in large quantities in building construction (steel, concrete) can be at least partially recycled, others are less recyclable and may become a disposal problem in the future. Examples include products that combine different materials (such as fiberglass composites) or undergo fundamental chemical change during manufacture (thermoset plastics such as polyurethane foams). Consider the future recyclability of products chosen.

Selecting Appropriate Materials

phase 5 – next use

step 11 = hazardous materials from demolition:

- Might the material be-come a toxic or hazardous waste problem after the end of its useful life? If not, proceed to step 11.
  - If yes (preservative-treated wood), seek alternative products or construction systems that require less of the material in question.

Selecting Appropriate Materials

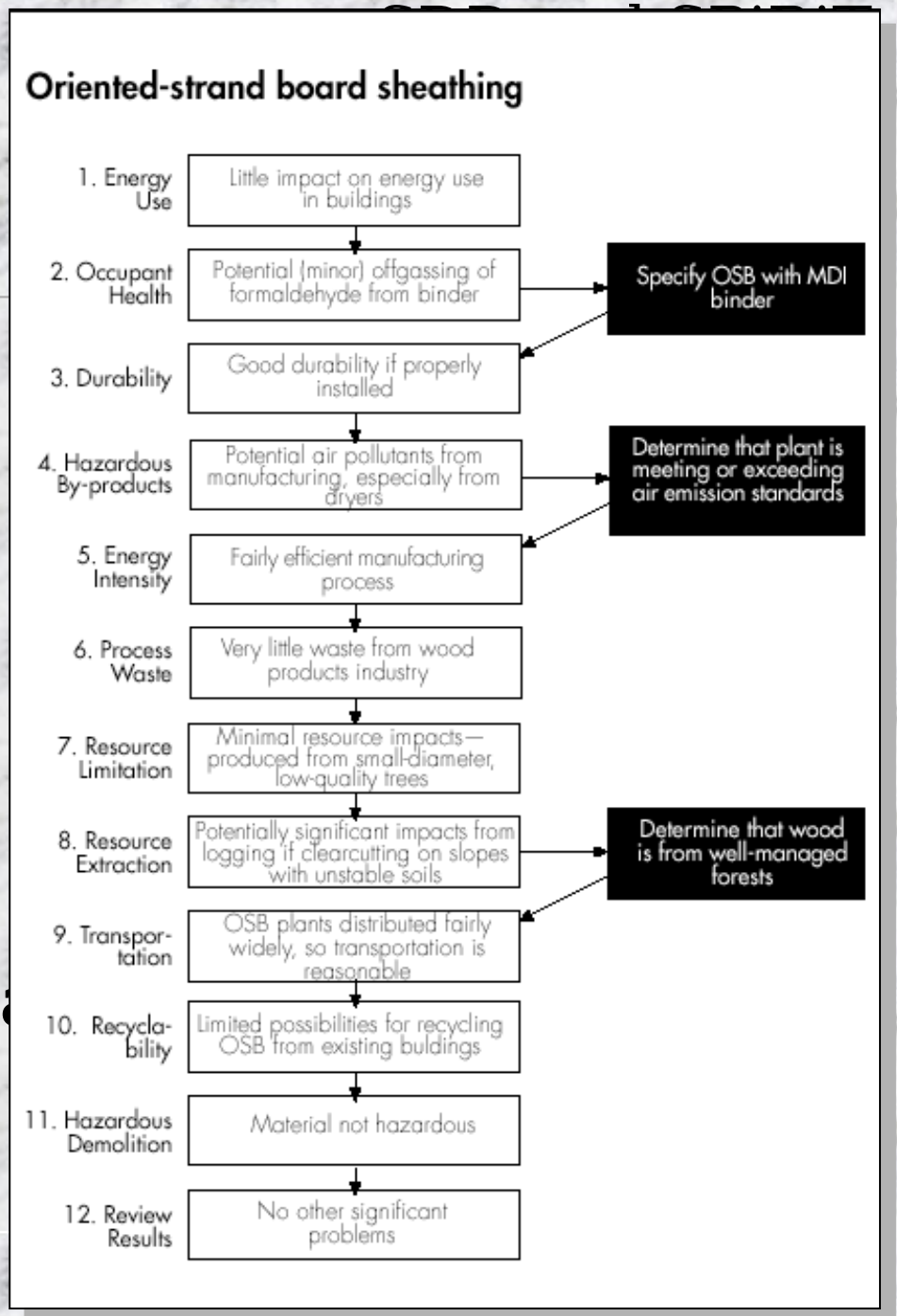
phase 5 - conclusions

step 12 – review the results:

- Go over any concerns that have been raised about the products under consideration, and look for other life-cycle impacts that might be specific to a particular material.
  - For example, with drywall and spray-in open-cell polyurethane foam insulation, waste generated at the job site is a potential problem that should be considered.

Materials Selection
example

- oriented strand boa


Oriented-strand board sheathing
1. Energy Use
Little impact on energy use in buildings
2. Occupant Health
Potential (minor) offgassing of formaldehyde from binder
Specify OSB with MDI binder
3. Durability
Good durability if properly installed
4. Hazardous By-products
Potential air pollutants from manufacturing, especially from dryers
Determine that plant is meeting or exceeding air emission standards
5. Energy Intensity
Fairly efficient manufacturing process
6. Process Waste
Very little waste from wood products industry
7. Resource Limitation
Minimal resource impacts—produced from small-diameter, low-quality trees
8. Resource Extraction
Potentially significant impacts from logging if clearcutting on slopes with unstable soils
Determine that wood is from well-managed forests
9. Transportation
OSB plants distributed fairly widely, so transportation is reasonable
10. Recyclability
Limited possibilities for recycling OSB from existing buildings
11. Hazardous Demolition
Material not hazardous
12. Review Results
No other significant problems

Materials Selection

- A simplified methodology for choosing the most environmentally benign materials (developed by EBN)
- The results of this process are only as good as the knowledge- base of those using it
- It does not take the place of a thorough understanding of the life-cycles of materials and their environmental impacts
  - this is a methodical way to apply that knowledge

VP	Very Poor
P	Poor
OK	Okay
G	Good
E	Excellent
?	?

Materials Comparison

PMP	Pollution in the Manufacturing Process
WRM	Waste Reduction in the Manufacturing Process
RC	Recycled Content
EER	Embodied Energy Reduction
NM	Natural Materials
RCW	Reduction in Construction Waste
LM	Local Materials
EE	Energy Efficiency
NTM	Nontoxic Materials
LL	Longer Life
REUSE	Reusablility
RECYC	Recyclability

FOUNDATIONS

foundations

	PMP	WRM	RC	EER	NM	RCW	LM	EE	NTM	LL	REUSE	RECYC
Poured-in-place Concrete	OK	G	G	P	E	OK	E	E	E	E	VP	VP
Concrete Block	OK	G	G	P	E	OK	E	E	E	E	VP	VP

STRUCTURAL FRAMING

framing

	PMP	WRM	RC	EER	NM	RCW	LM	EE	NTM	LL	REUSE	RECYC
Steel	P	G	E	VP	OK	?	E	VP	E	E	E	E
Wood	OK	G	VP	E	E	G	?	E	E	G	G	G
Engineered Lumber	?	G	E	E	E	G	?	E	P	G	?	G

BUILDING ENVELOPES

sheathing

	PMP	WRM	RC	EER	NM	RCW	LM	EE	NTM	LL	REUSE	RECYC
Plywood	P	OK	P	OK	E	G	G	G	VP	P	OK	G
OSB	P	E	G	G	E	G	G	G	P	VP	OK	G
Straw Paneling	E	E	E	E	E	G	OK	E	E	E	OK	G
Tectan	?	?	E	OK	E	?	?	G	?	OK	?	G

STRUCTURAL ENVELOPES

ext finish

	PMP	WRM	RC	EER	NM	RCW	LM	EE	NTM	LL	REUSE	RECYC
Strawable Construction	?	G	E	E	E	?	?	G	G	G	?	?
Stone	VP	OK	P	G	OK	VP	?	E	E	E	G	VP
CMU	P	G	G	P	E	OK	E	E	E	E	VP	VP
Brick	VP	?	OK	P	G	G	?	G	E	E	E	G
Adobe & Rammed Earth	E	E	G	E	E	E	OK	E	E	OK	P	G
Super Insulated Stress Skin Panels	?	E	G	E	?	E	?	E	OK	E	?	G
Ceramic Tile	G	G	E	OK	G	P	?	OK	G	E	VP	VP
Precast Concrete	P	G	G	P	E	OK	E	E	E	E	VP	VP

FLOORING

flooring

	PMP	WRM	RC	EER	NM	RCW	LM	EE	NTM	LL	REUSE	RECYC
Vinyl Flooring	P	?	P	P	OK	?	P	OK	VP	VP	VP	P
Linoleum	OK	?	P	P	E	?	P	OK	E	G	VP	VP
Wool Carpeting	?	?	?	?	E	?	?	?	E	G	?	?
Cork Tile Flooring	E	G	P	G	E	G	?	G	E	G	?	?
Ceramic Tile	OK	?	E	P	G	?	?	OK	G	E	?	P
Wood Flooring (bamboo)	E	?	P	G	E	?	?	G	G	G	G	?
Finished Concrete Flooring	OK	G	G	P	E	OK	E	E	E	E	VP	VP

VP	Very Poor
P	Poor
OK	Okay
G	Good
E	Excellent
?	?

Materials Comparison

PMP	Pollution in the Manufacturing Process
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LL	Longer Life
REUSE	Reusablility
RECYC	Recyclability

insulation

	PMP	WRM	RC	EER	NM	RCW	LM	EE	NTM	LL	REUSE	RECYC
Magnesium Silicate	G	?	P	E	G	?	?	G	E	OK	VP	OK
Cotton Insulation	G	E	E	G	E	OK	P	E	E	?	G	?
Fiberglass	VP	OK	OK	P	G	OK	P	G	VP	E	OK	P
Mineral Wool	G	G	E	P	G	?	?	G	P	E	OK	P
Cellulose	E	G	E	E	G	?	?	G	E	G	VP	?
Extruded Polystyrene	VP	P	G	VP	OK	?	P	G	P	G	G	VP
Expanded Polystyrene	P	P	G	P	OK	?	P	G	P	G	G	OK
Phenolic Foam	P	?	P	P	OK	?	VP	G	VP	OK	OK	VP
Perlite	P	?	P	?	E	?	?	OK	E	E	E	G
Vermiculite	P	?	P	?	P	?	VP	VP	OK	E	E	G
Polyisocyanurate	P	?	E	P	G	?	P	G	OK	OK	OK	VP
Polyurethane	P	?	E	P	G	?	P	G	OK	OK	OK	VP

roofing

	PMP	WRM	RC	EER	NM	RCW	LM	EE	NTM	LL	REUSE	RECYC
Slate	G	?	G	P	G	P	P	E	E	E	G	G
Imitation Slate	?	G	E	G	OK	G	?	E	G	E	?	?
Recycled Aluminum Shingles	?	E	E	P	G	E	?	E	G	E	?	G
Metal Panels	VP	?	E	P	OK	?	?	E	P	E	G	G
Asphalt or Fiberglass Shingles	VP	P	P	P	P	?	?	?	P	P	P	P
Cedar Shake	G	G	P	G	G	G	?	E	E	E	E	E
Clay Tile	OK	?	P	P	E	?	G	E	G	E	E	?
Concrete Tile	OK	OK	P	P	G	OK	G	P	G	E	?	P

finishes

	PMP	WRM	RC	EER	NM	RCW	LM	EE	NTM	LL	REUSE	RECYC
Gypsum Drywall	G	?	G	G	G	P	G	OK	G	G	OK	P
Plaster & Lath	P	?	P	G	G	?	G	E	G	E	VP	VP
Casein Paint	?	G	?	G	G	G	?	?	E	?	P	P
Wood Veneer	G	G	E	G	E	?	G	G	OK	G	G	G
Particle Board	P	?	P	P	P	?	OK	?	?	VP	E	P
Fiber-Reinforced Cement Board	P	?	E	P	G	OK	?	G	P	E	G	P

Case Studies

sustainable building materials

Thoreau Center for Sustainability

- **Architect: Tanner Leddy Maytum Stacy Architects**
- **Location: National Historic Landmark District of the Presidio in San Francisco, CA**
- **Functions as a center for non-profit organizations focused on environmental and sustainable development issues**
- **Cost: $55 per square foot**
- **73% of the materials removed during the renovation were recycled**
- **Awards:**
  - **National Trust for Historic**

Thoreau Center for Sustainability

Sustainable materials used:

- Recycled mineral and wool fiber ceiling tile, 85% recycled content (slag wool and cellulose fiber)
- Ceramic tile composed of 70% recycled glass
- Fiberboard made of 100% recycled paper
- Natural fiber, cotton, and cellulose (85% recycled newsprint) insulation
- 80% recycled content aluminum
- Medite composite panels made of 90% pre-consumer recycled wood (see lower right picture)
- toxic free paint - Safecoat

Southern California Gas Company

Energy Resource Center

- Architect: RLC Architects
- Location: Downey, California
- Functions as a center that showcases innovations in resource efficient designs, materials, and equipment to help consumers make informed choices about energy consumption and conservation
- Cost: $178 per square foot
- Building is 80% recycled
- U.S. EPA has designated the Energy Resource Center as an “Energy Star Building”
- Used 60% of the original structure to conserve resources

Southern California Gas Company

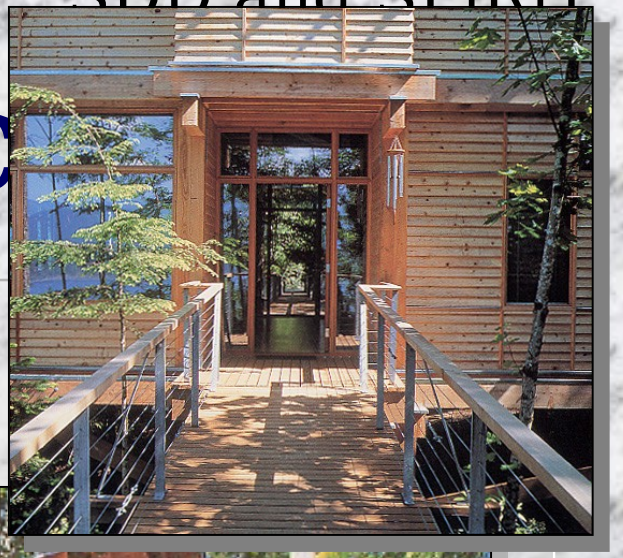
Energy Resource Center

Sustainable materials used:

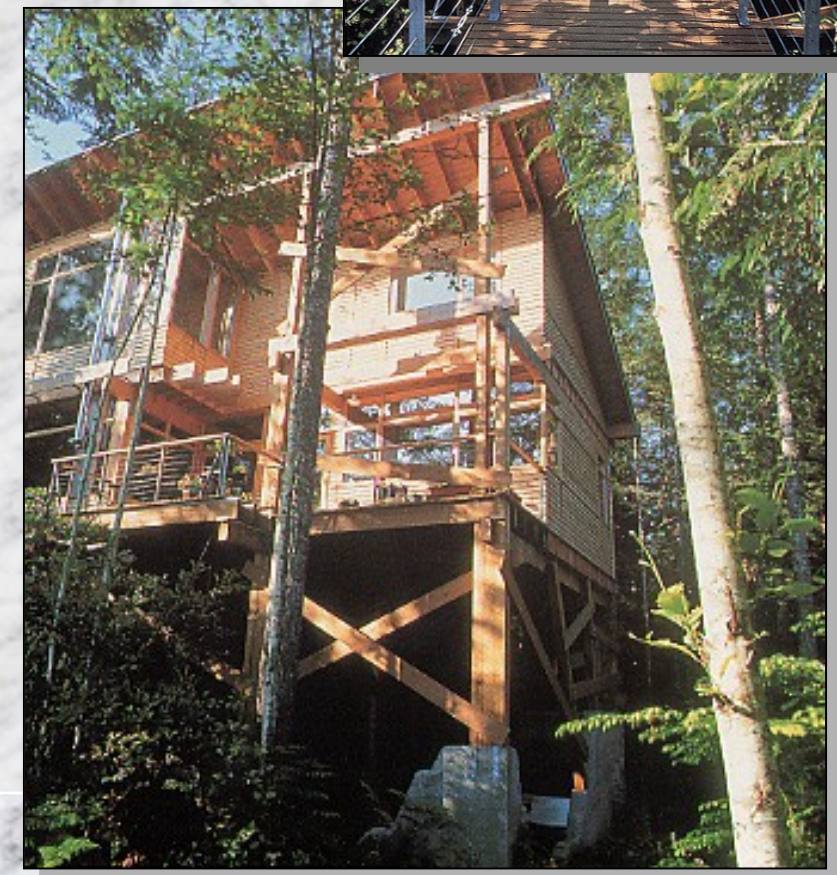
- Polystyrene concrete formwork
- Recycled weapons from L.A. County Sheriff's Dept. were used as reinforcing bars
- Recycled carpet tiles- 35% recycled post-industrial nylon

- Used poly-mar HD HPDE for bathroom partitions
  - 80% post-consumer recycled plastic
- Amofoam-Rcy
  - recycled insulation board
- Recycled wood floor from condemned warehouse
- Electrical conduit removed from original structure and reused

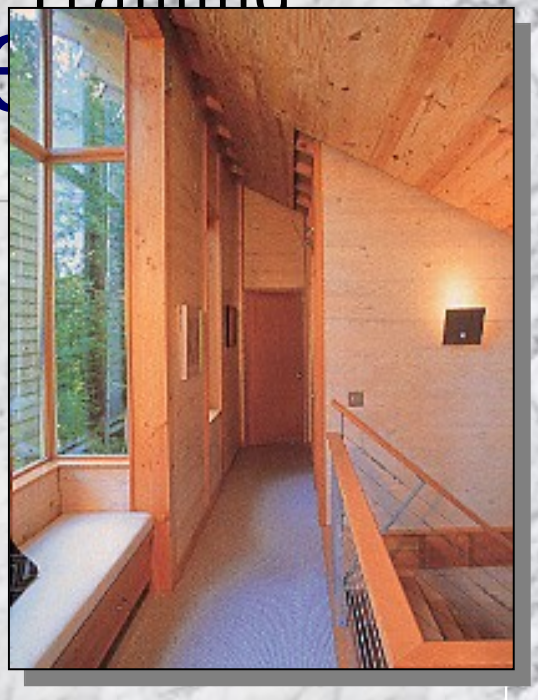
Paulk Residenc



- Architect: James Cutler Architects
- Location: Seabeck, Washington
- Functions as a private residence for John and Elinor Paulk with the objective to protect and nurture human awareness of the fragile nature of the earth's resources
- Cost: Withheld at owner's request
- Built with natural materials (except for vinyl tile in the bathroom) to minimize waste
- All materials were procured from local sources

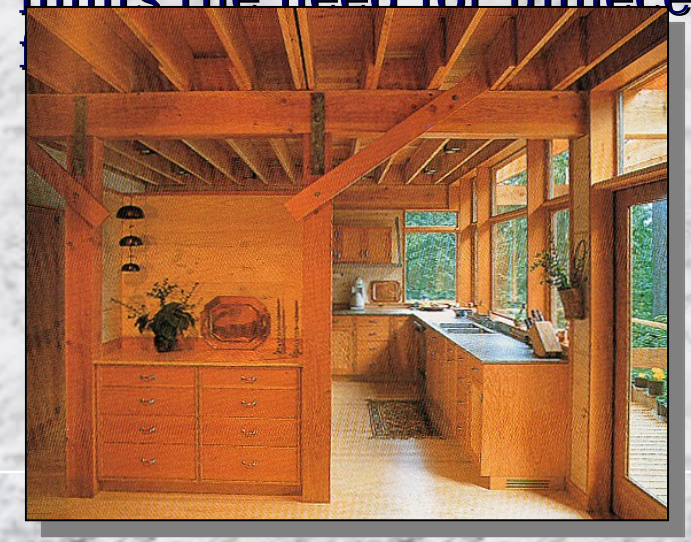


Paulk Residence



Sustainable materials used:

- Low-E mirror glazing with an R-value of 3.5
- Corridor at the second level is finished with natural woods and wool carpet
- Used natural wooden materials and left them exposed which limits the need for unnecessary



- Structure is built of second and third growth Douglas Fir and Pine which avoided the use of old growth lumber which is not renewable
- Toxic substances such as plywood or products containing formaldehyde are avoided or isolated

Materials Resources

- AARC Sourcebook http://www.usda.gov/aarc/aarcsrbk.html
- AEC Info Center http://www.aecinfo.com
- Carbohydrate Economy http://www.carbohydrateeconomy.org
- Environmental Home Center http://www.enviresource.com
- ESB Redi-Guide http://data.oikos.com/products
- Friedman & Sun Catalog http://www.friedman-sun.com/index
- Green Building Products http://www.recycle.net/ncra/gbdbase
- Green Seal http:// www.greenseal.org
- GreenSpec http://www.greenspec.com
- Harris Directory http://www.harrisdirectory.com
- Jade Mountain http://www.jademountain.com
- Recycled Content Products http://www.ciwmb.ca.gov/RCP/ http://www.metrokc.gov/market/map
- Rocky Mountain Ren Energy Resources http://ww.diac.com/~ggray/dbase
- Environmentally Preferable Goods http:// tbe.mit.edu/gallery
- US Green Building Council http://usgbc.org
- Rainwater harvesting http://www.twdb.state.tx.us/conservation/AltSource/Rain.htm
- CREST http://solstice.crest.org/sustainable/index.shtml
- DOE http://www.sustainable.doe.gov
- Environmental Building News http://www.ebuild.com

An Ethos

Seldom does anyone speak of the deficit involved in the closing down of the basic life systems of the planet through the abuse of the air, the soil, the water and the vegetation. Neither economic viability nor improvement in life conditions of the poor can be realized in such circumstances.

This deficit in its extreme expression is not only a resource deficit, but the death of a living process. which exists as far as we know only on the planet earth.

This deficit makes our problem different from those of any other generation of whatever ethnic, cultural, political or religious tradition, or of any other historical period.

For the first time we are determining the destinies of the earth in a comprehensive and irreversible manner.

Thomas Berry *The Dream of the Earth* from:
Agenda 2000: A Proposal for Leadership by the Environmental Design Professionals

More Examples

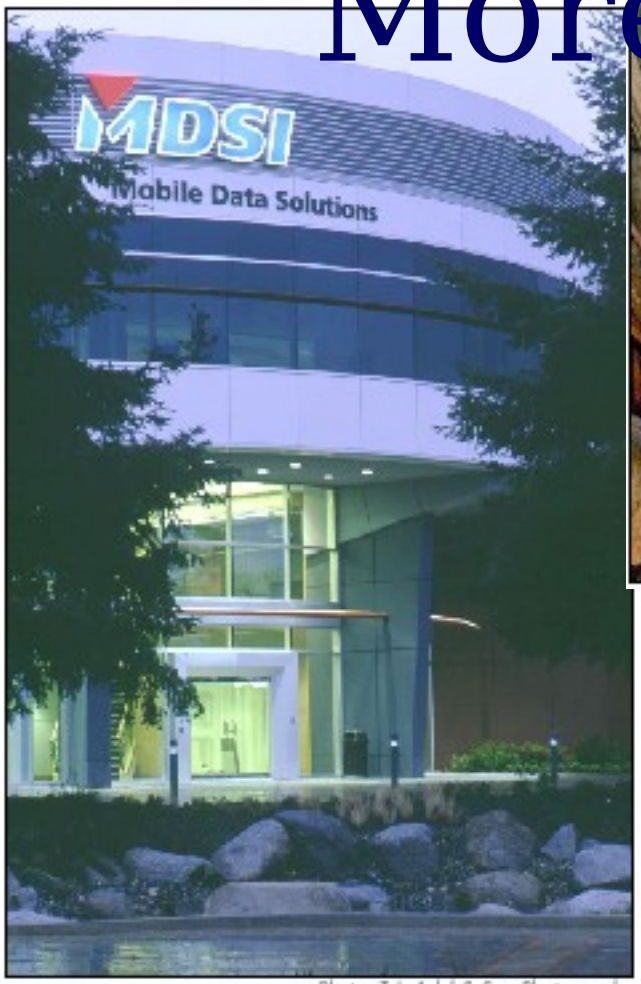


Photo: T.J. Adel & Son Photography

The Sun Life Building, leased by Mobile Data Solutions, Inc., is remarkably energy efficient for an office building built on a tight budget. The pond in the foreground is fed by rainwater from the building's roof. (See related story on page 6.)

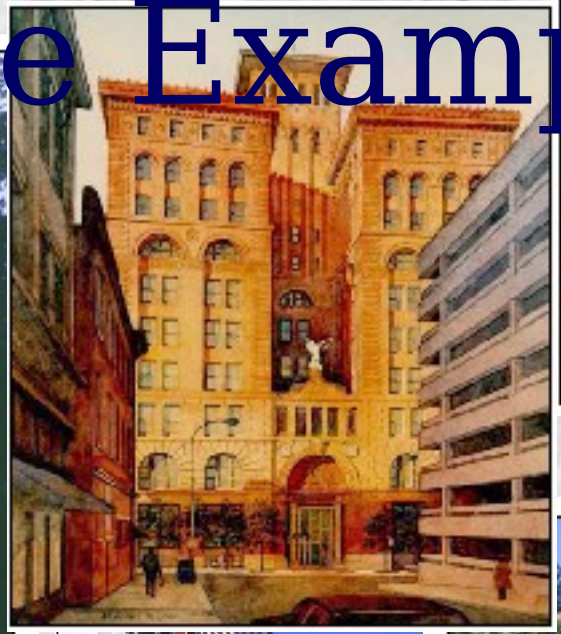


Photo courtesy of AIA/Portland [Gerlachs]

The 1987 Headquarters of the Emerald People's Utility District uses deciduous vines, light shelves, passive solar design, efficient lighting, and night flushing to reign in energy costs. The vines also soften the building's impact on its suburban neighborhood.